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(71) Applicant: DIAMETRICS MEDICAL, INC. [US/US]; 2658 Patton Road, Roseville, MN 55113 (US).

(72) Inventors: BLOMBERG, Scott, E.; 2775 Lexington, Roseville, MN 55127 (US). ANDERSON, Carter, R.; 4383 Hamilton Drive, Eagan, MN 55123 (US). SIN, Kee. Van; 7181 Sunfish Court, Lino Lakes, MN 55014 (US). MORRIS, Russell, L.; 2145 Niles Avenue, St. Paul, MN 55116 (US). DEETZ, Devid, W.; 2 Robb Farm Road, North Oaks, MN 55127 (US). ERBISCH, Kellie; 4901 Fifth Street N.E., Columbia Heights, MN 55421 (US).

(74) Agent: MERSEREAU, C., G.; Haugen and Nikolai, 820 International Centre, 900 Second Avenue South, Minneapolis, MN 55402 (US).

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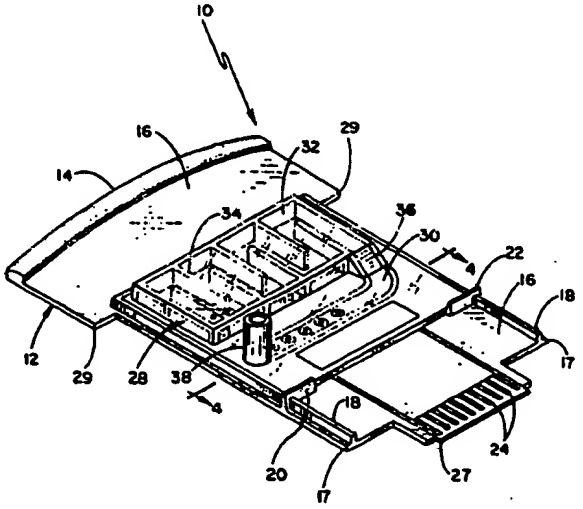

(57) Abstract

A disposable cartridge (10) for use in making electrochemical analytical determinations in the form of a plug-in test cartridge for one-time use with an associated analytical instrument such as a portable blood gas analyzer has a relatively flat base member (16), a handle (12) toward one end, designed to fit a plug-in port in the associated instrument. A raised housing (28) is fixed to the base member (16) that with the base member (16) defines internal flow through measurement chamber (30), a waste storage chamber (32) and connecting passage (36). A sample inlet port (38) in the housing accesses the measurement chamber (30). A sensor substrate (50) carrying an array of electrochemical sensors (40-48) and integral heater is fixed in the measurement chamber (36) and an electrical interface including a plurality of conductors (25) providing input/output connection to the electrochemical sensor array (40-48) and heater is provided. An amount of calibration medium is carried in the measurement chamber (30) to calibrate one or more of the electrochemical sensors (40-48).

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DISPOSABLE ELECTROCHEMICAL MEASUREMENT CARTRIDGE

BACKGROUND OF THE INVENTION

I. Cross-Reference to Related Application

Cross-reference is made to several co-pending applications including Serial No. 07/____,____, entitled "PORTABLE BLOOD GAS ANALYZER" filed of even date and assigned to the same assignee as the present invention; continuation-in-part application Serial No. 07/980,086, entitled "REFERENCE ELECTRODE", filed November 24, 1992; application Serial No. 07/964,583, entitled "SELF-ACTIVATING CHEMICAL SENSOR SYSTEM", filed October 21, 1992; application Serial No. 07/866,616, entitled "TEMPERATURE CONTROL FOR PORTABLE DIAGNOSTIC SYSTEM", filed May 21, 1992; application Serial No. 07/940,271, entitled "CALIBRATION MEDIUM CONTAINMENT SYSTEM", filed September 2, 1992; and application Serial No. 07/806,485, entitled "TEMPERATURE STABILIZED FLUID CALIBRATION SYSTEM", filed December 13, 1991, each of which is assigned to the same assignee as the present invention. To any extent necessary, material from all of the above are deemed incorporated herein by reference for any purpose of the present application.

II. Field of the Invention

The present invention is directed generally to stationary or portable diagnostic or electroanalytical devices of a class that perform electrochemical determinations on biological samples in which each fluid biological sample of interest extracted from the patient is characteristically analyzed for concentrations of specific species in solution. The apparatus is particularly characterized as one which employs a one-time use disposable cartridge containing an array of sensors for the pertinent species that respectively produce electrical signals indicative of the concentration of the species to an associated instrument which processes the signals and provides the relevant quantitative determinations. More particularly, the instant invention is focused on a self-

contained, single-use or disposable electroanalytical cartridge for use in an associated diagnostic or analytical instrument or device that is self-activating, self-calibrating and able to produce rapid accurate output signals, is low cost and requires a minimum amount of training and skills to operate.

III. Related Art

The measurement of certain chemical or physical characteristics of the blood can be quite important with respect to assessing the condition of a patient in a variety of clinical situations. The partial pressures of O_2 and CO_2, pH, together with the measurement of certain ions, such as Ca^{++} and/or K^+, provide important indications of the efficiency of the blood/gas exchange occurring in the lungs of the patient, relative acid/base balance and the concentration of certain indicative ion species in the blood, respectively. Such determinations are particularly critical in life-threatening circumstances.

Typical analyzers of the class traditionally employed in such determinations are costly, very complex devices. Most are permanently installed in the hospital laboratory and require highly-trained, skilled technicians to operate them successfully. Even the handling of the sample requires special attention inasmuch as analyzers of the class generally require a sample of blood taken from the patient to be transferred from the patient's location to the laboratory on an ice pack to better maintain sample integrity. The sample is then injected into a receiving device in the instrument. Care must be taken that the sample does not become contaminated as even contact with the ambient air is known to affect the accuracy of certain determinations including the pH reading.

Fixed analytical devices, of course, require that a sample be drawn from a patient, often at a location remote from the laboratory, transferred to the laboratory, analyzed and the results then carried back to the operating room, emergency room or other area of the hospital where

perhaps a life-threatening condition exists or a critical procedure is on-going.

This usually results in an undesirable, unavoidable lengthy delay between sampling and receipt of the results. The indications of such blood-gas analyses often are required to make proper adjustments in life-supporting or life-sustaining instruments which could be much more effectively employed were the results available to the attending physician sooner. Hence, devices that reduce the time required to make accurate determinations in order that proper, timely corrective steps may be taken are highly sought.

Additional drawbacks with respect to stationary laboratory electrochemical blood gas analysis instruments involve the nature of the devices themselves. These include the requirement for using very large reference electrodes for stability in conjunction with the pH, CO_2 and O_2 sensors, for example, along with the need for periodic recalibration and the running of frequent control samples to assess accuracy.

These systems must be calibrated using a calibration medium specifically designed for exposure and use only at one temperature, usually 37°C, and, in the case of a liquid-based calibration system, exposure to a temperature other than that designed for use may introduce a decided amount of error into the readings. The composition of calibration gas is not as temperature sensitive, but its use requires the availability of large cumbersome tanks or cylinders of compressed gas of known composition.

From the above, it is readily apparent that a portable blood-gas analysis system, particularly one providing a self-calibrating, rapidly responding analysis sensors which are not ambient temperature sensitive would be highly desirable and would provide a long-sought advance in the art and secure, to those working in critical care, a distinct advantage.

One on-site blood chemistry analytic device designed to connect to a heart/lung machine is described by Enzer et al in U.S. Patent 4 786 394. That system is designed to monitor critical parameters during open-heart surgery and employs a type of discardable sensor cartridge which contains a bank of sensors for making the electrochemical determinations. A further patent to Enzer et al (U.S. Patent 4 397 725) also discloses a clinical blood chemistry analyzer in which a discardable cartridge interfaces with an analytical machine.

It can readily be appreciated that there exists a need for the rapid response of a truly portable blood chemistry analysis device and, particularly, in conjunction therewith, a truly self-sufficient disposable cartridge system capable of instant activation and quick determinations. Accordingly, the present invention is directed to improvements in disposable cartridges for blood-gas or blood chemistry analytical devices of the class which interface with such cartridges. The particular focus of the invention is on the provision of an unique disposable cartridge system for use with an analytical device in the form of a low-cost system that is highly technically advanced, affording excellent accuracy and without the need of highly-trained personnel to operate the instrument and use the cartridge.

Accordingly, is it a primary object of the invention to provide a self-contained, disposable cartridge for analyzing bodily fluids that employs a low-cost, highly-accurate, multi-cell electrochemical sensor for use with a medical analyzer.

Another object of the invention is the provision of a disposable cartridge that is a portable device capable of receiving and processing the sample at the bedside of a patient.

Yet still another object of the invention is the provision of a disposable sample cartridge that includes an integral heating device.

A further object of the invention is to provide a self-contained electrochemical sensor cartridge having an autogenous calibration capability for pH, CO_2 and O_2.

A still further object of the invention is to provide a self-contained, disposable cartridge for analyzing bodily fluids capable of plugging into the external connection of an associated analytical signal processing instrument for providing a final output determination, which may be portable, needing only a plurality of electrical connections therebetween.

Still another object of the present invention is to provide a disposable, self-contained, automated calibration and sample testing cartridge complete with stabilized calibration material remaining in contact with selected electrodes until calibration is concluded, which is thereafter easily displaced by the sample solution to be analyzed.

A further object of the invention is the provision of a self-calibrating, disposable sample cartridge having flow control and storage volumes for used displacement calibration fluid.

Other objects and advantages of the invention will occur to those skilled in the art in conjunction with the specification and the several drawing views.

SUMMARY OF THE INVENTION

The present invention solves many of the problems of accuracy, speed, portability and cost with respect to a disposable multi-cell electrochemical sensor system for use in association with a larger medical analyzer device. The self-contained disposable cartridge of the invention is a low-cost, highly-accurate, multi-cell electrochemical sensor system which is capable of receiving a sample directly as extracted at the bedside of a patient and making a quick, accurate determination of pH, CO_2, O_2 and concentration of certain ions such as K^+ and Ca^{++}. The system is self-contained connected by multi-conductor electrical interface to an external plug unit on an

associated instrument which processes signals from the disposable sensor cartridge and makes the relevant determinations.

The disposable sample cartridge of the invention is generally a polymer encased device including an open sample receiving port, a low-volume flow-through cell containing a plurality of sensors used for blood gas analysis including a reference electrode and pH, pCO_2, pO_2, K^+ and other ion sensors, in a configuration in which the blood gas analysis is designed to be carried out on a fluid sample after automatic calibration of the sensor electrodes. The disposable cartridge is designed to be partially inserted and electrically interfaced into a larger instrument that contains all of the electronics and other support equipment to process the signals received from the disposable cartridge to accomplish the calibration and measurement using signals from the electrode system contacting the calibration material or sample fluid contained in the disposable cartridge.

The disposable cartridge is designed to accommodate or contain a system which automatically calibrates the electrodes after the cartridge is inserted and engaged in conjunction with the operation of the associated analytical instrument. The disposable cartridge preferably carries an array of sensors or a bank of aligned sensors on a ceramic chip which also contains an integral resistive heater element operated by a sensitive remote temperature sensor and input modulating temperature control system located in the instrument. The disposable cartridge further contains the calibration materials which, in the preferred embodiment, include the calibration species in gel media form. The gel with the calibration species therein is placed over the corresponding sensors during manufacture and remains in place during storage and shipment such that the calibration material is in situ in the flow-through chamber through the time of calibration. Thereafter, it is designed to be readily displaced by the injection of the

sample of interest, normally blood. Storage volume is provided for the calibration material which, after calibration is complete, is displaced by a sample introduced through the sample port. The sample, once infused, remains in the disposable cartridge with little danger of cross-contamination.

The disposable cartridge of the invention is further designed to have the calibration fluid remain in gas-permeable relation, as through the gel medium, with an external reservoir system packaged in conjunction with the disposable cartridge in a cartridge package or pouch that functions during the integrity of the package to control the concentration of species of interest dissolved in the calibration medium so that calibration can be accomplished accurately although the disposable cartridge be removed from the package at a temperature that varies over a range of ambient temperatures.

In the preferred embodiment, the disposable electrochemical sensor cartridge of the invention combines a molded base having a handle portion at one end and addresses an instrument injection port on the other. A housing mounted on the base provides a shallow sample chamber and a larger, deeper waste storage chamber. The sample chamber is situated over a bank of aligned sensors including a reference electrode or reference half-cell, a CO_2 electrode sensor, an O_2 electrode sensor and one or more metallic ion sensors. The sample chamber is located between an open inlet port accessible as by a sample syringe and a waste storage chamber which is provided for containing displaced calibration media, excess sample, or the like. The parts of the cartridge itself are made of readily moldable polymer materials and the relatively planar base carries the required electrical interface connectors.

In use, the sample cartridge is removed from its gas-tight shipping and storage environment, which may be metal coated PET (polyethylene terephthalate), for example,

containing the calibration media stabilizing reservoir materials and plugged into the analytical instrument, which may be portable. The calibration media is in place over the desired sensors to allow immediate calibration of the relevant sensors after the cartridge is plugged into the analytical instrument either automatically or upon switching the instrument to the ON position. Uncovered sensors, possibly the O_2 sensor, for example, are also ready for immediate calibration. Calibration is completed electronically and stored by the analytical instrument, the cartridge then being ready to receive a sample of blood or other designated bodily fluid via the sample inlet port.

The sample removed from the patient may be immediately injected into the sample inlet port of the calibrated sensor system with a portable device. The fluid sample displaces the calibration media, the bank of sensors having already been activated for production of signals yielding almost immediate analytical results. After the sample is transferred into the sample volume, the temperature control system operates as needed to stabilize the sample temperature, and the temperature of the analytical sensors to the desired 37°C or other desired temperature very rapidly. Thereafter, the output of the sensors quickly stabilizes and the analytical measurements conveyed in the form of electrical signals to the analytical instrument. The entire operation can be carried on in less than three minutes.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein like numerals are utilized to designate like parts throughout the same:

FIGURE 1 is a perspective view of the cartridge in accordance with the invention;

FIGURE 2 is an exploded view of the cartridge of Figure 1;

FIGURE 3 is a greatly enlarged plan view of a bank of aligned sensors of the disposable cartridge of the invention; and

FIGURE 4 is a front elevational view of the disposable cartridge of the invention.

DETAILED DESCRIPTION

It will be appreciated that the disposable cartridge of the invention may employ a combination of unique features and can take any one of a number of forms; and the following detailed description is intended to be representative of any of several configurations which might occur to those skilled in the art. Various unique aspects of the details of one or more embodiments of the disposable cartridge of the invention are described in greater detail in the several above cross-referenced, co-pending applications and which have been referred to as incorporated by reference in accordance with the detailed descriptions below. An important aspect of the invention is that the novel features also reduce the cost of the disposable cartridge so that the cartridge of the present invention may be primarily designed for one-time use as a throw-away or disposable to be used in conjunction with a portable testing device or even a stationary device adapted to receive cartridges of the type described. The details of one embodiment of the invention will next be described with particular reference to the several drawing Figures which are intended to be illustrative of the invention and not limiting as to the scope or configuration thereof in any manner.

Figure 1 illustrates a perspective view of a cartridge in accordance with the invention shown generally at 10 and includes a base member 16 and a housing 28 fixed to the base member shell constructed of sufficiently rugged polymer materials, such as a polycarbonate, to survive shipping, storing, handling and use without endangering delicate internal measurement components. One end of the base of the cartridge is formed to provide a handle 12 with gripping flange 14 provided for the user to grasp the cartridge. Integral flange members having horizontal portions 17 and vertical ribs 18 are formed in the member

16 for guiding the cartridge and provide structural support. Corresponding ears (not shown) associated with corners 29 and a receptacle of the diagnostic instrument for which the cartridge is designed to help hold the cartridge in place during operation. Further stop members associated with the insertion of the cartridge into the receptacle of the associated analytical instrument are shown at 20 and 22 designed to interface with stops in the analytical instrument when the cartridge 10 is fully inserted. The cartridge is further provided with an array of electrical conductor terminals 24 configured to connect with corresponding terminals in the instrument designed for use with the cartridge. These terminals and associated conductors 25 (Figure 2) provide the required cartridge/instrument interconnects including all necessary input and output connections to control the functions and transmit necessary signals between the cartridge and the analytical instrument. Conductors are typically laid down on a substrate as at 27 (Figure 2) using thick film technology or may be constructed in any well-known manner utilizing state-of-the-art techniques as desired. They are preferably deposited on the surface of the polymeric material or on a separate ceramic material as at 27, which is later attached to the polymer base 16 using thick or thin film technology as that has been found to be an appropriate and inexpensive technique, although others may occur to those skilled in the art.

Housing member 28 is attached to the molded or otherwise formed base member 16 and further defines with the base member a plurality of internal chambers. These include a shallow flow-through measurement cell chamber 30 (Figure 4) and a waste or excess sample storage chamber 32 which may be provided a plurality of partitions 34 forming a maze which helps maintain fluid once in the volume 32 from returning to the volume 30. The volume 32 is normally much larger than the volume 30 to accommodate overflow. These are separated by a passage as at 36.

The system preferably also includes an open sample inlet port 38 and a bank of in-line sensor electrodes including an oxygen electrode 40, a reference electrode system 48, and a plurality of additional measurement electrodes for pH, CO_2, etc. at 42, 44, and 46. The reference electrode system 48 may take any of several forms and preferably consists of an almost totally enclosed reference half-cell designed to be stored prior to use in contact with the calibration or storage medium which is displaced by the fluid sample on which the measurements are to be performed at the time of use. The storage material is selected to be compatible with the sample medium to be tested. The reference half-cell of the invention is simple and accurate for a time particularly suited to a sensor intended for disposal after a single use and is one that is easily miniaturizable at low cost and limited in size and cost only by the efficiency of thin or thick film fabrication techniques. The reference electrode associated with the cartridge of the invention is also one having a very small internal fill solution volume, in the order of 0.1 microliter, which can readily be adjusted for content in a configuration which maintains both the accuracy and integrity of the reference electrode half-cell during storage and for the time the cell is in use. Additional details regarding the reference electrode can be found in the above-referenced co-pending continuation-in-part application Serial No. 07/980,086.

Likewise, with respect to the oxygen sensing electrode 40, it is preferably a miniaturized gaseous oxygen chemical sensor cell calibrated by a gas phase and not using a reference gel or the like and capable of in-line disposition with liquid or gel calibrated or storage reference, pH and CO_2 and other measurement electrodes as at 42-46. Although it can take different forms within the contemplated scope of the present invention, the oxygen sensor system preferably includes an electrode system and what is initially a three-layer membrane/electrolyte

system. The three-layer system includes an outer composite hydrophilic layer that attracts water vapor combined with a middle gas-permeable polymer membrane barrier that transports water vapor molecules to the third layer, which is an inner electrolyte layer overlaying the electrode. Thus, as discussed below, the sensor is activated or rendered conductive by the amount of water vapor contained within the chamber 30 even during storage of the disposable cartridge of the invention so that the oxygen sensor, even though in a relatively dry state, is continuously active and ready to make an immediate measurement either with regard to a calibration medium or air or dissolved gas in a sample. A typical oxygen sensor for use with the aligned electrochemical sensor system of the disposable cartridge of the invention is fully described in the above cross-referenced co-pending application Serial No. 07/964,583.

The sensors 40-48 are preferably mounted or laid down on a relatively thin ceramic wafer or chip 50 by any of a number of well-known techniques. It will be appreciated with regard to the cartridge of the present application that the electrochemical measurement sensors require very little sample to accomplish accurate determinations and the small size also reduces the sensor size and amount of calibration fluid required in the packaged cartridge. It will be appreciated that the sensors of the disposable cartridge of the invention are generally applied using thin film or thick film techniques and are miniaturized to the extent possible based on the current state of the art.

The greatly enlarged view of Figure 3 depicts typical connections of the various sensors in the array with the input/output electrical connectors 25. The chip 50 also contains an electric heating element, which may be a thick film resistor in a basically serpentine pattern as at 52. That heater provides extremely rapid and accurate temperature control of the chip itself and, hence, the electrochemical sensors and sample contained in the volume 30. The volume of chamber 30 is kept quite small to allow

rapid determinations of great accuracy and ease of temperature control of the sample such that recovery from any temperature shock is rapid.

The heating resistor of the sample cartridge is designed to operate utilizing a remote infrared or other sensor probe and control system which controls the electric input to the resistor based on the sensed temperature of the reverse side of the chip (not shown) through a bottom opening in base member 26 in relation to a set point programmed in the analytical instrument itself. Such a system is further illustrated and described in greater detail in the above-referenced co-pending application Serial No. 07/866,616.

As packaged, stored and calibrated, the flow-through measurement cell of the disposable cartridge of the invention is provided with a calibration medium which is placed in the flow-through cell volume during manufacture of the cartridge. The medium may be in the form of a gel covering the electrodes, with the exception of the oxygen electrode (if a gas phase is being used as the oxygen electrode calibrant) or, if a liquid calibration medium is used, containment means are provided to maintain the calibrant in the flow-through sample or measurement cell until displaced by the sample itself during use.

Typically, the calibration medium is a solution or preferably a gel of selected solvents with or without complexing agents or buffers, the gel form being readily placeable over the sensors of interest such that it remains in place until calibration is achieved just prior to sample measurement and thereafter the calibrant is flushed out and removed by the introduction of the sample through the sample port. The stabilization of the calibrant itself within the flow-through measurement cell is illustrated and described in greater detail in the above cross-referenced, co-pending application Serial No. 07/940,271. As mentioned previously, it will be appreciated with regard to the calibration medium that the use of a gel eliminates the

need for any additional containment system with the calibration medium remaining in situ on its own until calibration is accomplished. Otherwise, as in the case with liquid systems, the structure of the disposable cartridge may have to be modified as by the provision of flow restriction devices to prevent loss of calibration fluid during shipment and storage prior to use.

An additional factor with respect to calibration concerns the stabilization of the calibration medium itself. The sample port of the raised housing assembly 28 fixed to the base member 26 is open or gas-permeable. The packaging of the disposable cartridge of the invention preferably further involves an operation that provides a stable concentration of the gases of interest in the calibration medium despite changes in temperature of the calibration medium or solvent within a reasonable range of ambient temperatures during storage prior to use. That temperature-independent system involves the use of an additional separate, reversible equilibrium-compensating source of the gas or gases of interest packaged along with the disposable cartridge in an overall essentially gas-tight package. The additional source, commonly known as a "reservoir", acts in the manner of a buffer to control changes in the partial pressure of the gas or gases of interest in the atmosphere of the package in a manner which controls the atmosphere contacting the calibration medium. In this manner, changes in partial pressure in the reservoir can be tailored to compensate for and dominate changes in the solubility of the gas or gases of interest in the calibration medium over a designed temperature range to remain substantially constant or to control change in the partial pressure of the species of interest as a desired function of temperature change. Details of that system are found in the above cross-referenced co-pending application Serial No. 07/806,485.

An important aspect of the present invention is the simplicity of the disposable cartridge in terms of

complexity of construction. As can be seen in Figure 2, the system contains relatively few, uncomplicated parts to be assembled. All the electrode sensors and conductors involved are extremely small and of extremely accurate but relatively simple construction. This allows the disposable cartridge of the invention to be readily manufactured and assembled at a sufficiently low cost that it makes economic sense as a single-use device.

This invention has been described herein in considerable detail in order to comply with the Patent Statutes and to provide those skilled in the art with the information needed to apply the novel principles and to construct and use embodiments of the example as required. However, it is to be understood that the invention can be carried out by specifically different devices and that various modifications can be accomplished without departing from the scope of the invention itself.

CLAIMS

We claim:

1. A self-contained self-calibrating disposable cartridge for the analysis of liquid samples and insertable for use with an associated diagnostic instrument comprising:

(a) a relatively flat base member having a handle toward one end and provided with a configuration detail toward the other, and including electrical connectors, designed to be received in a port of an associated instrument;

(b) a raised housing fixed to the base member and containing a dual-function chamber for calibration media storage and fluid sample analysis, said dual-function chamber defining a hollow interior and inlet and outlet accesses;

(c) a sensor substrate in said dual-function chamber;

(d) an array of electrochemical sensors and integral heater means carried by said sensor substrate;

(e) an amount of at least one compatible calibration material for calibrating a corresponding one or more of said electrochemical sensors predisposed and stored in the dual-function chamber and in contact with said corresponding one or more of said electrochemical sensors for immediate calibration thereof, said at least one calibration material further being of a type displaced by the introduction of a liquid sample to be analyzed to prevent cross-contamination;

(f) a plurality of conductors connected to the sensor electrodes for connecting the sensor electrodes to corresponding electrical connectors on said base member;

(g) enclosed hollow waste chamber in flow passage communication with the outlet access of the dual-function chamber and having sufficient capacity

to contain displaced calibration material and excess sample material; and

(h) sample access port for receiving a liquid sample to be analyzed in the dual-function chamber in fluid passage communication with the inlet access of the dual-function chamber.

2. The apparatus of claim 1 wherein the sensor substrate describes a thin generally planar shape defining opposite surfaces and wherein the array of electrochemical sensors together with an integral heater in the form of a thick film resistor means are carried on one surface, and wherein said plurality of conductors includes conductors connected to the thick film resistor.

3. The apparatus of claim 2 wherein the sensor substrate is a ceramic material.

4. The apparatus of claim 2 further comprising an access opening in said base member to expose a portion of a surface of said substrate opposite that carrying said integral heater for temperature sensing by a remote optical temperature control sensor.

5. The apparatus of claim 1 wherein the array of electrochemical sensors includes one or more gaseous species sensors and wherein the calibration material for the one or more gaseous species sensors is a gas phase in equilibrium with the one or more gaseous species sensors.

6. The apparatus of claim 5 wherein the one or more gaseous species sensors are activated from ambient water vapor in the disposable cartridge after fabrication and remains active during storage.

7. The apparatus of claim 1 wherein the array of electrochemical sensors includes an O_2 sensor and wherein the calibration material for the O_2 sensor is a gas phase in equilibrium with the O_2 sensor.

8. The apparatus of claim 5 wherein the O_2 sensor is activated from ambient water vapor in the disposable cartridge after fabrication and remains active during storage.

9. The apparatus of claim 1 wherein the array of electrochemical sensors includes a reference half-cell, pH, CO_2, and O_2 sensors.

10. The apparatus of claim 1 further comprising associated temperature stabilization means to stabilize said at least one calibration material over a range of storage temperatures during the storage thereof.

11. The apparatus of claim 9 further comprising associated temperature stabilization means to stabilize said at least one calibration material over a range of storage temperatures during the storage thereof.

12. The apparatus of claim 11 further comprising sealed storage means for containing the disposable cartridge, said storage means containing a separate equilibrium-maintaining buffer system to stabilize said at least one calibration material over a range of storage temperatures during the storage thereof.

13. The apparatus of claim 1 wherein the base member further includes stop means indicative of full insertion of the cartridge into the associated analytical instrument.

14. The apparatus of claim 1 wherein the base member is provided with guide members and flanges designed to engage matching recesses in the analytical instrument to support the disposable cartridge when in place in the analytical instrument.

15. A self-contained self-calibrating disposable cartridge for the analysis of liquid samples insertable for use with an associated diagnostic instrument comprising:

(a) a relatively flat base member having a handle toward one end and provided with a configuration detail toward the other, and including electrical connectors, designed to be received in a port of an associated instrument;

(b) a raised housing fixed to the base member and containing a dual-function chamber for calibration media storage and fluid sample

analysis, said dual-function chamber defining a hollow interior and inlet and outlet accesses;

(c) a relatively thin generally planar sensor substrate in said dual-function chamber;

(d) an array of electrochemical sensors and an integral resistance heater means carried by the upper surface of said sensor substrate;

(e) an amount of at least one compatible calibration material for calibrating a corresponding one or more of said electrochemical sensors predisposed and stored in the dual-function chamber and in contact with said corresponding one or more of said electrochemical sensors for immediate calibration thereof, said at least one calibration material further being of a type displaced by the introduction of a liquid sample to be analyzed to prevent cross-contamination;

(f) said base member further being provided with an access opening to expose a portion of the lower surface of said substrate carrying said integral resistance heater means for temperature sensing by a remote optical temperature control sensor;

(g) a plurality of conductors connected to the sensor electrodes for connecting the sensor electrodes and resistance heater to corresponding electrical connectors on said base member;

(h) enclosed hollow waste chamber in flow passage communication with the outlet access of the dual-function chamber and having sufficient capacity to contain displaced calibration material and excess sample material; and

(i) sample access port for receiving a liquid sample to be analyzed in the dual-function chamber in fluid passage communication with the inlet access of the dual-function chamber.

16. The apparatus of claim 13 wherein the sensor substrate is a ceramic material.

17. The apparatus of claim 15 wherein the array of electrochemical sensors includes a reference half-cell, pH, CO_2 and O_2 sensors.

18. The apparatus of claim 13 wherein the array of electrochemical sensors includes one or more gaseous species sensors and wherein the calibration material for the one or more gaseous species sensors is a gas phase in equilibrium with the one or more gaseous species sensors.

19. The apparatus of claim 13 wherein the one or more gaseous species sensors are activated from ambient water vapor in the disposable cartridge after fabrication and remains active during storage.

20. The apparatus of claim 15 wherein the array of electrochemical sensors includes an O_2 sensor and wherein the calibration material for the O_2 sensor is a gas phase in equilibrium with the O_2 sensor.

21. The apparatus of claim 15 wherein the O_2 sensor is activated from ambient water vapor in the disposable cartridge after fabrication and remains active during storage.

22. The apparatus of claim 15 further comprising associated temperature stabilization means to stabilize said at least one calibration material over a range of storage temperatures during the storage thereof.

23. The apparatus of claim 17 further comprising associated temperature stabilization means to stabilize said at least one calibration material over a range of storage temperatures during the storage thereof.

24. The apparatus of claim 23 further comprising sealed storage means for containing the disposable cartridge, said storage means containing a separate equilibrium-maintaining buffer system to stabilize said at least one calibration material over a range of storage temperatures during the storage thereof.

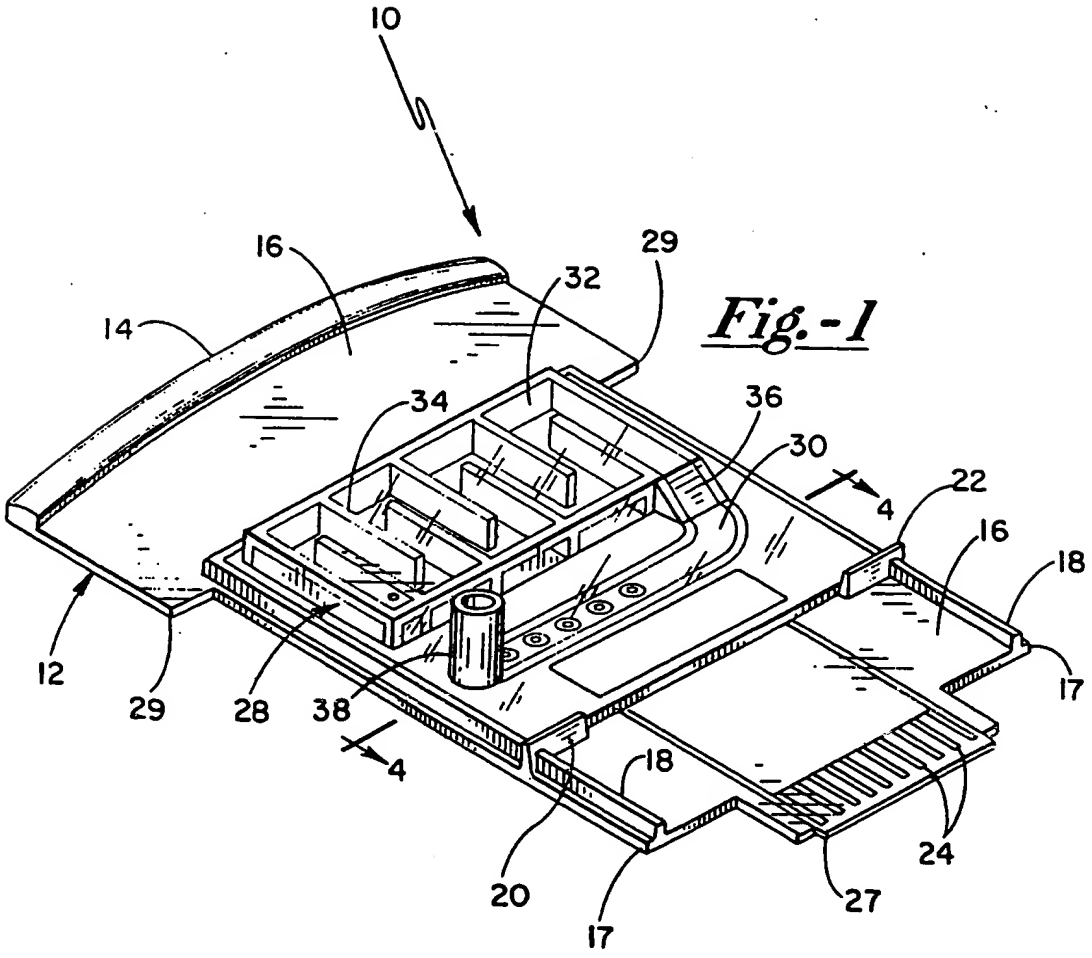


Fig.-1

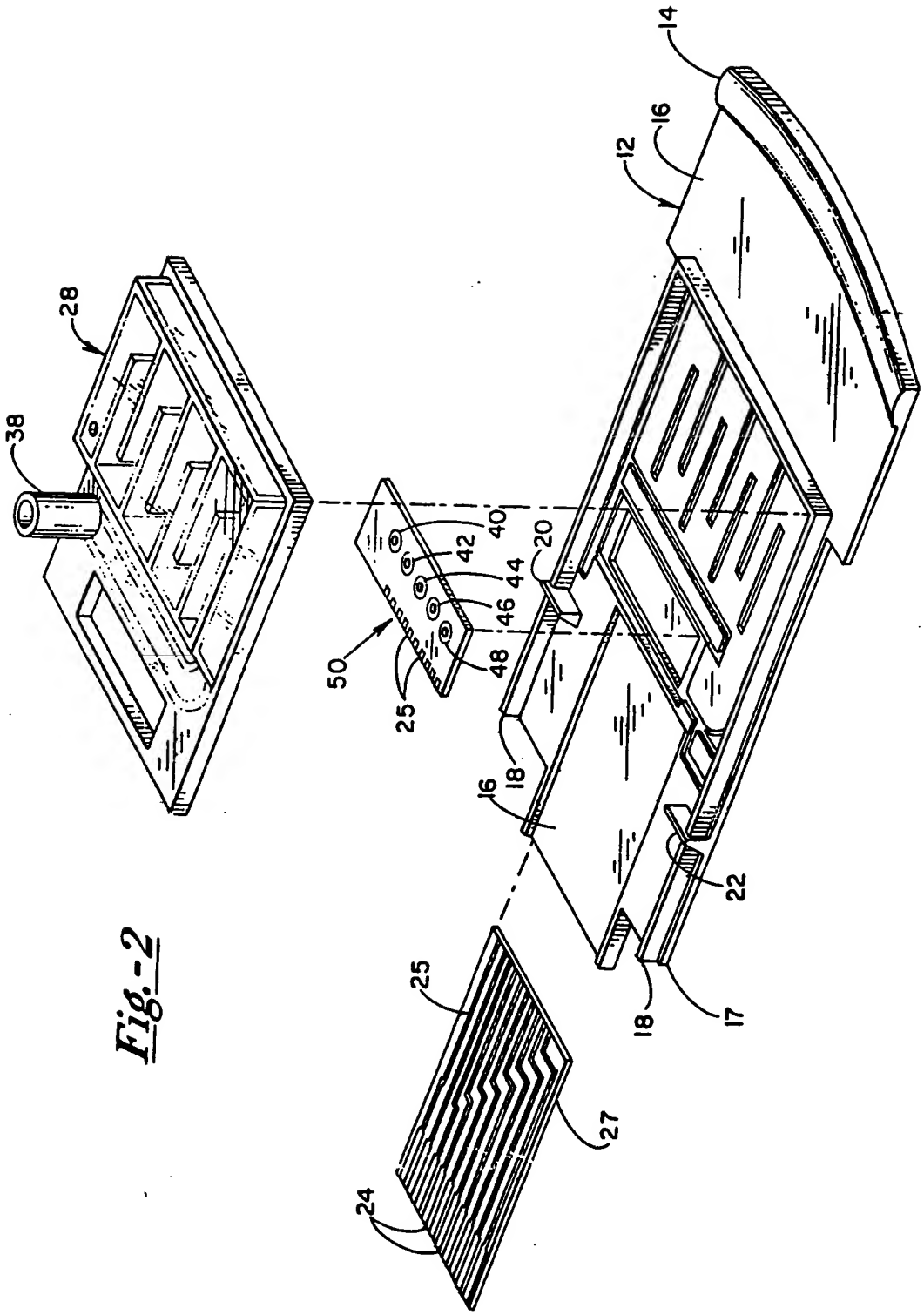


Fig.-2

Fig.-3

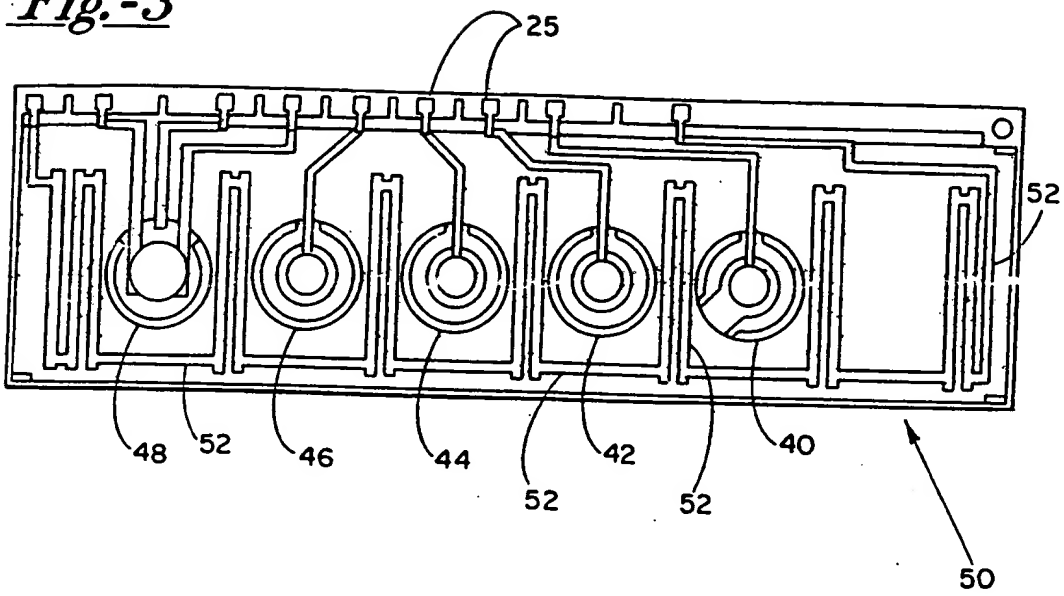
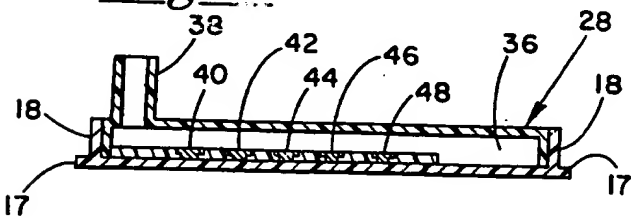


Fig.-4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/01760

A. CLASSIFICATION OF SUBJECT MATTER
IPC(5) : G01N 27/26
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 204/403, 409, 416, 422, 433, 435, 418, 419; 422/82.03; 128/635; 435/291,817

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
none

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
none

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A 4,654,127 (Baker et al) 31 March 1987 (see fig. 2; col. 2, lines 64-68; col. 3, lines 1-40; Col. 4, lines 1-68) and col. 5, lines 1-50).	12-35
Y	US,A 4,871,439 (Enzer et al) 03 October 1989 (Col. 3, lines 59-65)	18, 20, 28, 31
Y	US,A 5,004,583 (Guruswamy et al) 02 April 1991 (col. 13, lines 27-50)	24, 25
Y	US,A 4,900,405 (Otagawa et al) 13 February 1990 (Col. 15, lines 63-65)	14, 27

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
28 APRIL 1994

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MAY 24 1994

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
JOHN NIEBLING
Telephone No. (703) 308-0661

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PCT/US94/01760

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US CL :

204/403, 409, 416, 422, 433, 435, 418, 419; 422/82.03; 128/635; 435/291,817